Communications Equipment

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Communications Equipment: Industry Overview

Silicon Photonics: Not Ready for Primetime Yet

- Over the last 18 months, analysts and industry experts have debated silicon photonics and the implication of the technology for traditional optical component suppliers. **Our view on the technology, its applications, and potential threat to component suppliers has not changed and is exaggerated by those suggesting incumbent component suppliers face a grave threat.** We summarize recent developments and provide a framework to better understand the current and future market role of silicon photonics. We consider exposure for Finisar, JDS Uniphase, Applied Optoelectronics, and others.

- We segregated the market for silicon photonics into three buckets within datacenters: very short-reach, short-reach, and long-reach. **We think silicon photonics flourishes in very short-reach applications currently not served by optical component suppliers; we do not expect much presence in short-reach applications but silicon photonics could be somewhat disruptive in long-reach applications, however the technology needs to be developed and proven which will take time.**

- We think investors placed silicon photonics in one category as early technological advancement in very-short reach interfaces was extrapolated to other applications of optical components. That confusion was also fueled by optical component suppliers’ marketing departments as they used the term silicon photonics hoping to gain investor attention. **Given that the term “silicon photonics” has been used out of context numerous times, we think only truly differentiated products with significant cost, density, and power advantages over traditional components should be labeled silicon photonics.** As such we do not include Cisco’s CPAK under the silicon photonics umbrella as we believe it is a customer rather than a technology threat to optical component suppliers.

- **Recent M&A transactions indicated that silicon photonics would not be as disruptive as many investors thought.** One of the highest profile silicon photonics private companies, Kotura, was acquired by Mellanox for just $82 million in 2013. In contrast, Finisar spends over $150 million in R&D annually. **We think companies such as Finisar and JDS Uniphase could have easily acquired Kotura or another silicon photonics start-up for less than $100 million and put to rest investor concerns that led to multiple contraction.** Rather, the modest $82 million demonstrates the threat is modest.

- The adoption of optical in datacenters bodes well for several firms including Finisar, Avago, and Applied Optoelectronics; even JDS Uniphase is ramping. If the component players ceased product development, then silicon photonics would pose an eventual threat. **Current development timelines suggest new products counter the threat.** We expect Finisar and JDS Uniphase to either develop silicon photonics technology internally or acquire it as they see fit to target emerging applications largely addressed by metallic media today. We think datacom-exposed optical component companies could be most at risk from a silicon photonics evolution that could potentially result in long-reach 100G transceivers priced considerably below current 100G offerings, but developments will narrow the gap. We expect it will take time for the emerging silicon photonics products to reach the market; thus, presenting an evolving landscape and a typical race to move down cost curves between incumbents and start-ups. In our coverage universe, Finisar has the most exposure in datacom at 70% of sales followed by JDS Uniphase at less than 10% of sales. Applied Optoelectronics derives over 20% of its sales from datacom but does not compete in the 100G segment today.

Please read domestic and foreign disclosure/risk information beginning on page 12 and Analyst Certification on page 12.
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### Overview of Silicon Photonics

In broad terms, silicon photonics encompasses a range of applications referring to the fabrication of photonic communication devices using standard CMOS (Complementary Metal-Oxide Semiconductor) processing techniques. Silicon can be used in various degrees in wafer development based on a manufacturer’s proprietary technology, and this is where, in our opinion, the term has been misused. We do not expect all aspects of current optical functions to be performed in silicon given some of its physical limitations but rather a hybrid approach that uses best practices from optics and CMOS processing.

Silicon photonics enables the integration of a number of functions currently performed by individual optical components onto a single chip. The main advantages of such implementation are lower power and higher density while increasing reliability. Photonic integration is nothing new. Infinera has long been using in-house designed Photonic Integrated Circuits (PICs) in its systems, while component supplier NeoPhotonics uses PIC technology to manufacture a significant portion of its product portfolio (NeoPhotonics applies PIC technology primarily to passive components compared to Infinera’s active components approach). Although, PIC-based devices can also offer lower power, higher density, and reliability compared to discrete component solutions, it is the use of silicon and the CMOS process that make silicon photonics solutions attractive given the potentially lower material and manufacturing cost.

### Advantages

- Leverage investments already made in the semiconductor industry and outsource development to CMOS foundries
- Wafers grown with the CMOS process can offer high yield and manufacturing scale
- Component integration could increase reliability
- Potentially lower power, cost, and higher density
- Does not need the latest and greatest CMOS process

### Disadvantages

- Silicon by itself does not lase and III-V materials (i.e., compounds of materials from column III and V of the periodic table) such as indium phosphide need to be integrated into the silicon
- Moore’s law does not apply given optical signal loss limitations
Datacenter infrastructure has been one of the faster growing areas for IT networking driven by the ever-increasing need for a higher and faster number of connections between servers and switches. One of the characteristics of datacenters is the need for low cost, high performance, high density, and low power networking connections. A solution that would lower cost, power, and footprint would be welcomed by datacenter operators and as such silicon photonics could potentially play an important role in delivering these requirements. The datacenter market for networking was $9.6 billion in CY12 according to Infonetics and is expected to increase to $12.6 billion in CY17.

One trend has been the increasing size of datacenters, hence increasing the need for longer-reach optics in the datacenter. According to Infonetics, the portion of short-reach transceivers in datacom addressing distances less than 100 meters was 86% in CY12 but is expected to drop to 83% in CY17. On the revenue side, the short versus longer reach split is expected to be 43% and 47% in CY12 and CY17, respectively, mainly on speed-related product mix.

We segregate the datacenter market into three categories: very short-reach interfaces, short-reach interfaces, and long-reach interfaces.

**Very Short-Reach Interfaces**

We consider very short-reach interfaces connections within a single rack where distances are limited to around three meters. These connections are not currently served by optics and connectivity could be board-to-board or chip-to-chip. This is an area where Intel has done significant work on silicon photonics solutions, not surprising in our opinion as it would help with its microprocessor sales. This is also an area where privately owned Luxtera has historically focused its silicon photonics efforts. We think the push of silicon photonics in this area created confusion among investors that extrapolated this use case to other applications of optical components. Transmission over copper media can be accommodated within a single rack for speeds up to 40 Gbps, but with 100 Gbps transmission limited to one meter over copper the use of optics is necessary.

As we mentioned previously, **very short-reach interfaces are currently not served by optics hence there is no threat to traditional optical component suppliers.** As a result, this area could potentially serve as an incremental opportunity for optical components manufacturers although we think silicon photonics solutions likely dominate.
Short-Reach Interfaces

We consider short-reach interfaces connections that are typically less than 100 meters in length. These interfaces currently constitute the lion’s share of optical networking in datacenters with the majority of these connections served by 10G VCSELs (Vertical-Cavity Surface-Emitting Lasers) and SFP+ transceivers predominately offered by vendors such as Finisar and Avago. The advantage of VCSEL technology is that light is emitted from the top surface of the device and as result VCSEL chips can be tested on the wafer before packaged into individual devices (in contrast, telecom and longer-distance datacom lasers are edge-emitting lasers). This characteristic reduces the fabrication cost of these devices. In addition, the larger output aperture of VCSELs increases the coupling efficiency with optical fiber addressing one of the biggest bottlenecks in component manufacturing. As a result, VCSELs have above-average production yields and can be produced in very high volumes. The disadvantage of VCSELs is the lower power emission compared to edge-emitting lasers thereby limiting their application to short distances. We think that VCSELs have significant advantages regarding cost, yields, and power consumption and as such we do not envision silicon photonics participating in this market segment in the foreseeable future.

Long-Reach Interfaces

We consider long-reach interfaces connections that are typically more than 100 meters in length. Transceivers used in this category consist of edge-emitting DML (directly modulated) or EML (externally modulated) lasers. Unlike VCSELs that operate at 850 nm wavelength (light color), longer-reach lasers operate at 1,310 nm wavelength for datacom applications and 1,550 nm wavelength for telecom applications, and are typically orders of magnitude more expensive than VCSELs. The transceiver cage predominately used for 10G long-reach datacenter optics is the MSA (multi-source agreement)-compliant SFP+ form factor, which is the same form factor as the one used for VCSEL-based short-reach optics.

For higher-speed transmissions of 40G or 100G there are two MSA form-factor families available, the QSFP+ (40G, 100G) and the CFP (100G). The latter has been mentioned in numerous debates given that its form-factor roadmap competes with Cisco’s CPAK solution as we will later discuss. According to Infonetics, the price for a 40G long-reach QSFP+ transceiver averaged $1,300 in CY12 with the price declining to around $800 in CY13. In contrast, the price of a 100G CFP transceiver averaged $11,500 in CY12 with the price declining to around $8,500 in CY13 and $5,000 in CY14.

Silicon photonics start-ups Kotura and Luxtera have approached the market from a different perspective aiming to provide 100G transmission using a QSFP+ package instead of a CFP package. The QSFP+ package is slightly denser than the CFP4 and already exists on equipment front panels that use 40G QSFP+ transceivers. Kotura expects to deliver 100G QSFP+ transceivers with a price point of around $1,000 and power consumption of less than 4W (Watts), in line with the power specification of a CFP4 transceiver as defined by the MSA. Keep in mind that CFP4 transceivers may not be commercially available until 2015. Similarly, Luxtera expects to deliver 100G transceivers priced at less than $1,000 while consuming less than 3W of power. Although QSFP+ solutions offer similar power consumption to the CFP4 in a denser package, their power dissipation is worse than the CFP4’s and as such their performance over long distances trails the CFP4’s. We think long-reach optical interfaces could be an area where successful implementation of silicon photonics technology could potentially alter optical component suppliers’ market share dynamics, but we envision execution risk.
The optical datacom transceiver market was dominated by 10G ports in CY12 that resulted in 68% of “10G & beyond” revenue compared to 12% and 19% for 40G and 100G, respectively. We think that the 10G market continues to do well in the out-years driven by copper-to-optical (1G to 10G) port migration remaining the majority of the market at over 50% through CY17.
Early Example of Silicon Photonics – Active Optical Cables (AOC)

Molex’s acquisition of Luxtera’s Active Optical Cable (AOC) technology in 2011 showed the potential for silicon photonics in a datacom application. AOCs are comprised of a fiber cable with embedded transceivers at both ends. Mainly used for board-to-board or rack-to-rack connections, AOC provides an easy and reliable way to establish electrical-to-optical-to-electrical connections. Similar to copper cabling, AOC accepts electrical inputs and thus maintains compatibility with standard electrical interfaces but uses fiber for the transmission of information resulting in increased speed and distance performance.

Source: Chipworks, Raymond James research.

Cisco’s CPAK – A Customer Rather Than a Technology Threat

Cisco’s internal approach to 100G optical transceivers, the CPAK, resulted in numerous discussions about technological differences to the CFP family of transceivers and the threat to the optical component supply chain. Cisco had indicated in the past that the CFP family roadmap was not progressing fast enough and as such decided to acquire Lightwire for $271 million in 2012 and subsequently introduce its own 100G transceiver – the CPAK. We think Cisco developed this technology in an effort to differentiate its systems from competitors and achieve greater port densities while consuming less power than the CFP, which at the time was the only commercially available product. Since then a number of component vendors including Finisar have introduced the CFP2, which is comparable to CPAK yet still lags slightly in density and power consumption. Finisar demonstrated a short-reach CFP4 prototype at the ECOC tradeshow in September 2013 but volume production is not expected until 2H14-1H15.
<table>
<thead>
<tr>
<th></th>
<th>CFP</th>
<th>CFP2</th>
<th>CFP4</th>
<th>CPAK</th>
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<tr>
<td>Power</td>
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<td>Front Panel Bandwidth</td>
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<td>1.6-1.8 Tb</td>
<td>1Tb</td>
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Source: Cisco, CFP MSA, Raymond James research.

Regardless of the technological gap between the CPAK and CFP2 (not that significant in our opinion), investors often do not realize that in this particular case the vertical integration by a system vendor threatens the optical component suppliers and not the technology itself. Cisco has designed its future 100G systems to be compatible with the CPAK, therefore even if the CFP2 outpaces it then the CPAK is likely to continue to be in use. Instead, the latest evolution of the CFP family, the CFP4, or the 100G QSFP+, could compete head-to-head with the CPAK and potentially designed into Cisco’s systems.

### Intel’s Solution – Focus on Rack-Level Interconnects

Intel has done considerable work on silicon photonics starting as early as 2004 and has published a number of technical papers outlining its research. Most of this research has been focused on achieving functionality of discrete optical components on silicon, which are the building blocks necessary to produce a wafer chip capable of performing optical transceiver functions. Intel announced a significant milestone in 2006, the development of a hybrid silicon laser using the standard CMOS process, but it was not until 2010 when Intel demonstrated a 50G end-to-end silicon photonics link with integrated lasers. In this demonstration, Intel used two chips, one on the transmitter side that combines light beams from four hybrid silicon lasers each operating at 12.5G after modulation and one chip on the receiver side where the optical beams are separated and light is converted to electricity for subsequent processing.
We think Intel’s technology will focus on very-short reach interfaces within racks, where connections such as board-to-board or chip-to-chip are currently not served by optics. Given the large number of potential connections, Intel could leverage economies of scale and create new revenue streams while helping with its microprocessor sales. In September 2013, Intel announced the availability of its silicon photonics technology within its Rack Scale Architecture (RSA). This is an example where copper cables could be replaced by optical fibers each operating at 25G based on the announced configuration. Longer term, we think Intel expands beyond the datacenter to consumer applications in an attempt to bring its technology to the masses.

Potential Disruption of Silicon Photonics – 100G QSFP+ Transceivers

Kotura and Luxtera have been proponents of 100G transmission using the QSFP+ form factor. This particular form factor is already used for 40G transmission in datacenter networking and is the evolution of the SFP+ form factor, which is mainly used for 10G transmission. QSFP+ and SFP+ form factors are widely available on front panels of datacenter switches. On the other hand, 100G transmission is currently handled by the CFP form factor, which is designed to operate at the edges of a datacenter and as such it can be found on edge router line cards. As previously mentioned, the CFP is a family of form factors that includes the CFP, the CFP2, and the CFP4. We think that the CFP2, similar to the CFP, addresses edge routing needs and it is not until the introduction of the CFP4 when it gets deployed inside the datacenter.
Kotura is using two chips in its 100G QSFP+ transceiver, one on the laser side and one on the receiver side. The material used for the laser is indium phosphide (InP), while silicon germanium (SiGe) is used for the detectors/receivers. Everything else is done in silicon. Similar to a 100G CFP transceiver, four 25G signals are combined (multiplexed) to produce a 100G signal. Low cost External Cavity (EC) lasers are used that include hybrid laser cavity (part of the cavity within the InP device and the rest in the silicon photonics waveguide). The transmitter chip includes four lasers, a grating that sets each laser’s wavelength, four modulators, and a WDM multiplexer to combine the four wavelengths before transmission on the fiber. The receiver chip uses a four-channel demultiplexer with each channel fed to a SiGe photo-detector. Kotura’s solution also features passive alignment, wafer scale testing, and die-attached CMOS driver array and Transimpedance Amplifiers (TIAs) thereby reducing assembly costs.

Luxtera on the other hand uses a single chip for transmission and detection compared to Kotura’s two-chip approach. A DFB laser is coupled with the silicon photonics chip that includes four modulators and four receivers. Similar to Kotura’s approach, the four receivers are using germanium material that is grown on the silicon chip. Luxtera expects 100G QSFP+ transceivers based on its aforementioned chip to fetch around $1,000 when in production.

Although these products have yet to be proven in long-reach datacenter transmission applications, if the price points claimed by Kotura and Luxtera can be achieved while maintaining performance requirements then we imagine significant headwinds for traditional optical component suppliers given that 100G transceivers are currently sold for more than $7,000. Nevertheless, we think a realistic time frame for these devices is 2015 and by then the 100G CFP2 will be offered at around $3,000, which is still at a considerable premium. Although QSFP+ solutions offer similar power consumption to the CFP4 in a denser package, their power dissipation is lower than the CFP4’s and as such their performance over long distances trails the CFP4’s. As such, 100G QSFP+ transceivers might not be preferred by equipment vendors despite their potentially lower prices. We think the acquisition price paid for Kotura by Mellanox of just $82 million in 2013 likely signals that the technology is not as disruptive. In contrast, Finisar spends over $150 million in R&D annually. We think companies such as Finisar and JDS Uniphase could have easily acquired Kotura or another silicon photonics start-up for less than $100 million and put to rest investor concerns that led to multiples contraction.
Beyond Kotura and Luxtera

Apart from Kotura and Luxtera, two other privately held companies, Skorpios and Aurrion, have reported technological advancements in silicon photonics.

Skorpios

Skorpios was founded in 2009, and in 2011 received $21 million in Series B financing. Investors included Ericsson, Nokia Siemens Networks, and Deutsche Telekom. Similar to Luxtera’s one-chip approach, Skorpios’ technology enables the integration of optical functions including light generation, detection, and modulation with existing CMOS technologies on a single chip. This approach results in lower cost and power consumption, and higher density.

Skorpios’ chips use building blocks referred to as “macrocells”, typically perform one optical function, and mainly include lasers, receivers, and modulators. These building blocks can be combined with CMOS control electronics to be designed to customer-specific needs. This modular approach allows Skorpios to tailor its products to customer specifications and reduce typical development expenses of new products. Although we do not envision Skorpios competing directly with the optical component merchant market, its ties with equipment vendors position Skorpios to potentially benefit from specialized needs.

Aurrion

Aurrion was founded in 2007 with the vision to integrate the advantages of photonics and silicon-based processes to offer low cost, high density solutions in the datacom and telecom optical communications markets. Aurrion’s technology leverages the economies of scale of CMOS manufacturing by utilizing silicon and the performance of non-silicon materials critical for meeting transmission requirements.

Unlike Luxtera’s solution where the laser is separated from the silicon chip, Aurrion’s platform integrates InP-based semiconductor material onto existing silicon photonics substrates thereby enabling all photonic functions to be brought together onto a single chip including light generation, modulation, and detection. Aurrion’s approach uses InP to also construct modulators and detectors in contrast to Kotura and Luxtera that both use germanium to build their receivers. Furthermore, Aurrion aims to fabricate telecom and datacom chips on the same wafer, which is a strategy that would result in better utilization rates and lower cost through economies of scale.

Telecom (left) and Datacom (right) Solutions That Could Be Grown on the Same Multi-Project Wafer (MPW)
Silicon Photonics Influenced M&A

There has been considerable M&A activity around silicon photonics, which has not been isolated within the component space as systems vendors have also participated. One of the first transactions was the acquisition of Luxtera’s silicon photonics-based Active Optical Cable (AOC) business by Molex (Molex was recently acquired by Koch Industries) in 2011. The acquisition added QSFP+ active optical cables to Molex’s activity optical connective product portfolio. In addition, the acquisition included an exclusive agreement for Luxtera to supply chip sets for future Molex products for the Ethernet and InfiniBand markets.

Perhaps the highest profile acquisition that brought silicon photonics into the spotlight was Cisco’s acquisition of Lightwire for $271 million in 2012. Lightwire had immaterial revenue at the time of the acquisition. This acquisition made investors aware of silicon photonics technology and started a debate about the threat of this technology to the traditional optical components supply chain. The acquisition was a way for Cisco to develop a proprietary optical interface that would result in differentiated systems that could eclipse competition.

In August 2013, Mellanox closed the acquisition of Kotura for $82 million, an amount that in our view suggests that the opportunity for silicon photonics could not be as significant as many in the investment community may have thought. Earlier, in July 2013, Mellanox also closed the acquisition of iPtronics, a provider of driver solutions that are used in conjunction with optical components, for $49.5 million in what we think was an attempt by Mellanox to eventually integrate not only the typical optical functions onto one chip but also to integrate electrical functions onto that same chip. Huawei’s acquisition of Caliopa, a start-up based in Belgium, in September 2013 offered a validation point to Cisco’s strategy (i.e., system differentiation by offering vertically-integrated proprietary technology). Note that about a decade ago, system vendors got rid of internal development and manufacturing of optical components only to start again with selective vertical integration.

Another transaction that took place in 2013 was the acquisition of CyOptics by Avago for about $400 million, the largest deal in the optical components space over the last decade. We think Avago acquired CyOptics for its 40G/100G portfolio in order to extend its datacom portfolio to longer-reach applications. CyOptics’ technology is not categorized as silicon photonics, but is rather similar to the photonic integration capabilities of traditional optical component suppliers.
# The Silicon Photonics Ecosystem

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<th>Company</th>
<th>Headquarters</th>
<th>Description</th>
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<tr>
<td><strong>Ecosystem Players</strong></td>
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<tr>
<td>Acacia</td>
<td>Maynard, MA</td>
<td>Vision of developing systems based on advanced modulation techniques that integrate high speed optics and electronics. Initial core products are transceivers aimed at telecom applications at 100Gbps transmissions and beyond.</td>
<td>2009</td>
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<tr>
<td>Aurion</td>
<td>Goleta, CA</td>
<td>Developed a process to make multiple lasers on a wafer and attempting to bridge the volume/performance gap between datacom and telecom. Expects to be able to achieve 400Gbps for datacom applications.</td>
<td>2007</td>
</tr>
<tr>
<td>Cisco</td>
<td>San Jose, CA</td>
<td>Heavily invested in SiPh after acquiring Lightwave for $274M in 2012, which has been integrated into its transceivers and modules business. Developed a proprietary package called CPACK, which Cisco believes offers size and power advantages over existing packages.</td>
<td>1/84</td>
</tr>
<tr>
<td>Compass EoT</td>
<td>Netanya, Israel</td>
<td>Developed an optical router that allows for chip-to-chip optical communications and is intended to boost bandwidth and reduce footprint by eliminating all electronic switching fabrics. Has gone the systems route vs. the vendor route.</td>
<td>2005</td>
</tr>
<tr>
<td>Intel</td>
<td>Santa Clara, CA</td>
<td>Investing heavily in Silicon Photonics and has unveiled part of its strategy through the introduction of its 50Gb/s link and rack scale architecture. Intel intends to be a significant player in 100Gb/s optical interconnects.</td>
<td>1/68</td>
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<tr>
<td>Luxtera</td>
<td>Carlsbad, CA</td>
<td>Established player, first developing a 10Gb/s optical modulator in CMOS in '05. Special ability to couple light effectively to the silicon-based parts that provide intelligence in the module. Works with STM for production of high volume SiPh products and has shipped 500K+ AOC parts.</td>
<td>2001</td>
</tr>
<tr>
<td>Scorpios</td>
<td>Albuquerque, NM</td>
<td>Focused on integrating active optical components into wafer scale standard CMOS processes. In 2015, demonstrated a CMOS tunable laser, capable of meeting specifications for data center interconnects and high-performance coherent long-haul systems exceeding 100Gbps.</td>
<td>2009</td>
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| **Laser Source Companies** | | | |
| Avago | Singapore, Singapore | Competitor in the data center whose capabilities increased with the recent acquisition of CyOptics, an optical modules player with capabilities in 40/100Gb/s telecom and datacom. | 2005 |
| Binoptics | Ithaca, NY | Unique and scalable approach to SiPh through proprietary non-hermetic process, where chips don't need to be wrapped with a seal of metal, ceramic, glass, etc. | 2000 |

| **Cabling Companies** | | | |
| Metamaterials | Yokneam, Israel | Moved into SiPh with acquisitions of Kotura and pTronics for $350M. Kotura packages a 100Gb/s transceiver in a standard QSFP+ package and demonstrated 100Gb/s transmission with 3.5W of power. pTronics enables in-house production/packaging of the entire transceiver. | 1/99 |
| Molex | Lisle, IL | Purchased Luxtera’s active optical cable business and began a partnership for the development of future products. Molex may launch a 100Gb/s QSFP+ transceiver and thinks SiPh will become a very large part of the single mode optics market in the data center. | 1/38 |
| TE Connectivity | Schaffhausen, Switzerland | Have made a big push recently to explore SiPh technologies and could be planning to include the technology in its connector cables. | 2007 |

Source: Raymond James research.

## Company Citations

<table>
<thead>
<tr>
<th>Company Citations</th>
<th>Ticker</th>
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<td>FNSR</td>
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<td>23.14</td>
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Notes: Prices are as of the most recent close on the indicated exchange and may not be in US$. See Disclosure section for rating definitions. Stocks that do not trade on a U.S. national exchange may not be registered for sale in all U.S. states. NC=not covered.
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Raymond James & Associates (U.S.) definitions

Strong Buy (SB1) Expected to appreciate, produce a total return of at least 15%, and outperform the S&P 500 over the next six to 12 months. For higher yielding and more conservative equities, such as REITs and certain MLPs, a total return of at least 15% is expected to be realized over the next 12 months.
Outperform (MO2) Expected to appreciate and outperform the S&P 500 over the next 12-18 months. For higher yielding and more conservative equities, such as REITs and certain MLPs, an Outperform rating is used for securities where we are comfortable with the relative safety of the dividend and expect a total return modestly exceeding the dividend yield over the next 12-18 months.

Market Perform (MP3) Expected to perform generally in line with the S&P 500 over the next 12 months.

Underperform (MU4) Expected to underperform the S&P 500 or its sector over the next six to 12 months and should be sold.

Suspended (S) The rating and price target have been suspended temporarily. This action may be due to market events that made coverage impracticable, or to comply with applicable regulations or firm policies in certain circumstances, including when Raymond James may be providing investment banking services to the company. The previous rating and price target are no longer in effect for this security and should not be relied upon.

Raymond James Ltd. (Canada) definitions

Strong Buy (SB1) The stock is expected to appreciate and produce a total return of at least 15% and outperform the S&P/TSX Composite Index over the next six months.

Outperform (MO2) The stock is expected to appreciate and outperform the S&P/TSX Composite Index over the next twelve months.

Market Perform (MP3) The stock is expected to perform in line with the underlying country index.

Underperform (MU4) The stock is expected to underperform the underlying country index.

Suspended (S) The rating and price target have been suspended temporarily. This action may be due to market events that made coverage impracticable, or to comply with applicable regulations or firm policies in certain circumstances, including when Raymond James may be providing investment banking services to the company. The previous rating and price target are no longer in effect for this security and should not be relied upon.

Raymond James Latin American rating definitions

Strong Buy (SB1) Expected to appreciate and produce a total return of at least 25.0% over the next twelve months.

Outperform (MO2) Expected to appreciate and produce a total return of between 15.0% and 25.0% over the next twelve months.

Market Perform (MP3) Expected to perform in line with the underlying country index.

Underperform (MU4) Expected to underperform the underlying country index.

Suspended (S) The rating and target price have been suspended temporarily. This action may be due to market events that made coverage impracticable, or to comply with applicable regulations or firm policies in certain circumstances, including when Raymond James may be providing investment banking services to the company. The previous rating and price target are no longer in effect for this security and should not be relied upon.

Raymond James Euro Equities, SAS rating definitions

Strong Buy (MO2) Expected to appreciate, produce a total return of at least 15%, and outperform the Stoxx 600 over the next 6 to 12 months.

Outperform (MO2) Expected to appreciate and outperform the Stoxx 600 over the next 12 months.

Market Perform (MO2) Expected to perform generally in line with the Stoxx 600 over the next 12 months.

Underperform (MO2) Expected to underperform the Stoxx 600 or its sector over the next 6 to 12 months.

Suspended (S) The rating and target price have been suspended temporarily. This action may be due to market events that made coverage impracticable, or to comply with applicable regulations or firm policies in certain circumstances, including when Raymond James may be providing investment banking services to the company. The previous rating and target price are no longer in effect for this security and should not be relied upon.

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Rating Distributions

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<th>Coverage Universe Rating Distribution</th>
<th>Investment Banking Distribution</th>
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<tbody>
<tr>
<td>RJA</td>
<td>RJL</td>
</tr>
<tr>
<td>Strong Buy and Outperform (Buy)</td>
<td>51%</td>
</tr>
<tr>
<td>Market Perform (Hold)</td>
<td>43%</td>
</tr>
<tr>
<td>Underperform (Sell)</td>
<td>6%</td>
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</table>

Suitability Categories (SR)

Total Return (TR) Lower risk equities possessing dividend yields above that of the S&P 500 and greater stability of principal.

Growth (G) Low to average risk equities with sound financials, more consistent earnings growth, at least a small dividend, and the potential for long-term price appreciation.
Aggressive Growth (AG) Medium or higher risk equities of companies in fast growing and competitive industries, with less predictable earnings and acceptable, but possibly more leveraged balance sheets.

High Risk (HR) Companies with less predictable earnings (or losses), rapidly changing market dynamics, financial and competitive issues, higher price volatility (beta), and risk of principal.

Venture Risk (VR) Companies with a short or unprofitable operating history, limited or less predictable revenues, very high risk associated with success, and a substantial risk of principal.

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<table>
<thead>
<tr>
<th>Company Name</th>
<th>Disclosure</th>
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<tbody>
<tr>
<td>Applied Optoelectronics, Inc.</td>
<td>Raymond James &amp; Associates lead-managed an initial public offering of AAOI shares within the past 12 months. Raymond James &amp; Associates makes a market in shares of AAOI. Raymond James &amp; Associates received non-investment banking securities-related compensation from AAOI within the past 12 months.</td>
</tr>
<tr>
<td>Cisco Systems</td>
<td>Raymond James &amp; Associates makes a market in shares of CSCO. Raymond James &amp; Associates received non-investment banking securities-related compensation from CSCO within the past 12 months.</td>
</tr>
<tr>
<td>Finisar Corporation</td>
<td>Raymond James &amp; Associates makes a market in shares of FNSR.</td>
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<tr>
<td>Intel Corporation</td>
<td>Raymond James &amp; Associates makes a market in shares of INTC.</td>
</tr>
<tr>
<td>JDS Uniphase</td>
<td>Raymond James &amp; Associates makes a market in shares of JDSU.</td>
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</tbody>
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Stock Charts, Target Prices, and Valuation Methodologies

Valuation Methodology: The Raymond James methodology for assigning ratings and target prices includes a number of qualitative and quantitative factors including an assessment of industry size, structure, business trends and overall attractiveness; management effectiveness; competition; visibility; financial condition, and expected total return, among other factors. These factors are subject to change depending on overall economic conditions or industry- or company-specific occurrences. Only stocks rated Strong Buy (SB1) or Outperform (MO2) have target prices and thus valuation methodologies.

Target Prices: The information below indicates target price and rating changes for the subject companies included in this research.

Valuation Methodology: We value Applied Optoelectronics on price to earnings and enterprise value to sales bases.
Valuation Methodology: We value Cisco based on a combination of forward looking earnings multiples, price to revenue multiples, and enterprise value to EBITDA multiples. We believe this accurately reflects the strong absolute value of earnings, the strong earnings growth rate, the inherent profitability, and adjusted balance sheet factors.

Valuation Methodology: We value Finisar based on a combination of forward looking earnings multiples, price to revenue multiples, and enterprise value to revenue ratios. We believe this accurately reflects the strong absolute value of earnings, the strong earnings growth rate, the inherent profitability, and adjusted balance sheet factors.
Valuation Methodology: Our valuation methodology for INTC is based on a P/E multiple comparison to its historical forward P/E range.

Valuation Methodology: We value JDSU on price to earnings and enterprise value to sales bases.

Risk Factors

General Risk Factors: Following are some general risk factors that pertain to the projected target prices included on Raymond James research: (1) Industry fundamentals with respect to customer demand or product/service pricing could change and adversely impact expected revenues and earnings; (2) Issues relating to major competitors or market shares or new product expectations could change investor attitudes toward the sector or this stock; (3) Unforeseen developments with respect to the management, financial condition or accounting policies or practices could alter the prospective valuation; or (4) External factors that affect the U.S. economy, interest rates, the U.S. dollar or major segments of the economy could alter investor confidence and investment.
prospects. International investments involve additional risks such as currency fluctuations, differing financial accounting standards, and possible political and economic instability.

**Specific Investment Risks Related to the Industry or Issuer**

**Communications Equipment Industry Risks**
Industry risks include customer concentration, product cycle delays, softer than expected North American capital investments in 2014, the potential slowing of specific initiatives such as 4G/LTE, and the potential revenue impact from the migration to SDN (software defined network) and NFV (network function virtualization) technologies.

**Company-Specific Risks for Applied Optoelectronics, Inc.**
Risks for Applied Optoelectronics include: timing of the inventory absorption by systems manufacturers; price competition within a fragmented market for optical components; reduced capital expenditures at telco and CATV customers; reduced capital expenditures at enterprise customers; and market share shifts due to the introduction of new technologies or solutions.

**Company-Specific Risks for Cisco Systems**
Risks for Cisco Systems include: slowing router sales; reduced capital expenditures at telco customers; reduced capital expenditures at enterprise customers; competitive enterprise offerings; and slow uptake of Advanced Technologies.

**Company-Specific Risks for Finisar Corporation**
Risks for Finisar include: timing of the inventory absorption by systems manufacturers; price competition within a fragmented market for optical components; reduced capital expenditures at telco customers; reduced capital expenditures at enterprise customers; and market share shifts due to the introduction of new technologies or solutions.

**Company-Specific Risks for Intel Corporation**
Risks that could potentially impact Intel's results include margin pressure due to underutilization of fabs, PC and communications end-market weakness, competition from ARM-based vendors in mobile, PC and server end-markets, poor execution of manufacturing upgrades, and a slowdown in semiconductor growth,

**Company-Specific Risks for JDS Uniphase**
Risks to our investment thesis on JDSU include slowing capital expenditures, pricing pressure, and market share losses.

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